3.0 Family of Seats

A family of seats is a group of seat assemblies regardless of the number of seat places, built from equivalent components in the primary load path. Aft and side facing seats by definition are a separate seat family from forward facing seats.

The primary load path for structural tests typically includes seat components such as seat legs; lateral beams (cross tubes), spreaders, cushion supports and cushions, seatbelts and their attachments, attachments between structural members, seat track fittings and energy absorbers (Note: energy absorbers are normally integrated into the other seat components). The strength and deformation responses of these members are evaluated during structural tests.

The typical primary load path for lumbar load tests include bottom cushions, bottom cushion supports, and lateral beams (cross tubes). Also part of this load path are seat legs, spreaders, attachments between structural members, seat track fittings, and energy absorbers.

The typical primary load path for row-to-row HIC tests include components in the seat assemblies such as components installed on the seat back (e.g., food tray tables, video monitors, telephones, etc.), recline mechanism, breakover devices, seat back energy absorbers, seat back attachment hardware, and in some cases, arm rests.

The typical primary load path for head/knee path tests is the same as those for the structural tests.

In addition, some components (i.e., bottom cushions, bottom cushion support, armrests, and seat backs) affect the positioning of the occupant in the seat place that can influence ATD dynamic response and occupant injury criteria.

The discussion below describes common primary load-path components typically found in passenger seats. The components in the primary load path for each specific seat part number must be analyzed to ensure they fall within the family concept. Substantiation of variations to these components is also discussed below. These variations should be examined both between seat assemblies or within a single seat assembly.

While the discussion below addresses the evaluation of seat components as individual members, the dynamic performance of the entire seat assembly with all variations/modifications incorporated must also be evaluated against the tested seat assemblies. For example: a seat with variations from the tested seat in legs, beams *and* spreaders, might also require test, even though the change in any one element might not require test.

Seat Family Definition

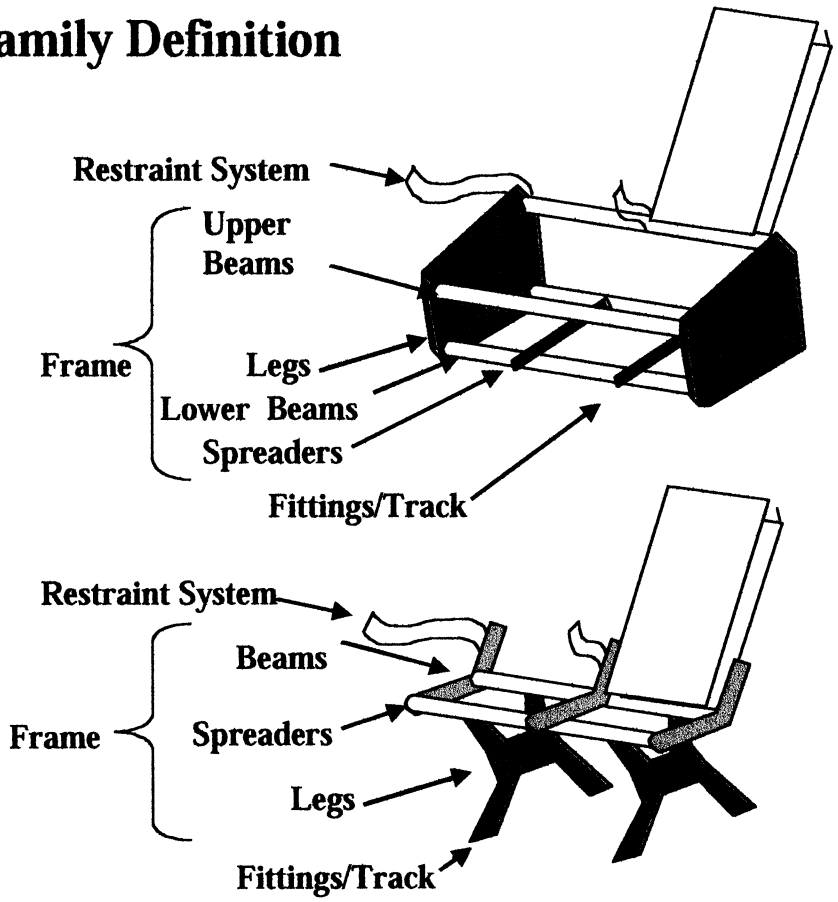
Primary Load Path Elements
Special tests should not be run addressing elements not on the primary load path. Aft facing seats by definition are a separate seat family from forward facing seats

Other Primary Load Path Elements
(not pictured)

Seat Back
(row to row HIC)
(Primary load path for aft facing seats)

Attach Fittings
(e.g. between spreaders and beams)

Bottom Cushion Seat Pan



Each section below will be structured as follows:

- Description of the family concept/principles governing that component
- Discussion and guidelines for variations within the family, which are acceptable using rational analyses without test. This is generally for changes that do not make that feature more critical than the tested feature.
- Discussion and guidelines for variations in a seat family which will require test.

The usage of the term "variations" denotes variations and changes/modifications made post test, post certification, or resulting from failures.

3.1 Seat Legs

a) *Family of Seat Principles* - Seat legs are typically the vertical structural members of the seat that provide the load path from the upper seat structure (e.g. upper beams, pan, etc.) to the lower seat structure (lower beams, track fittings, etc.). Energy absorbers may be incorporated into the seat leg design (see section 9). To be eligible to belong in a particular seat family seat legs must have the same design philosophy, section properties, and energy absorber (if used).

Note: Seat track fittings that interface with aircraft structure are covered below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat leg geometry are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s). For example, an increase in distance between the front and rear fitting would be acceptable provided it could be shown by rational analysis that (see appendix A):

- The floor fitting loads are equivalent to or less critical than the seat leg of the tested seat (e.g., linear interface loads analysis), and
- The strength of the portion of the leg that varies to accommodate the increase in distance is equivalent to or less critical than the seat leg of the tested seat
- The stiffness of the leg is similar to the critical leg in the longitudinal and vertical load conditions.

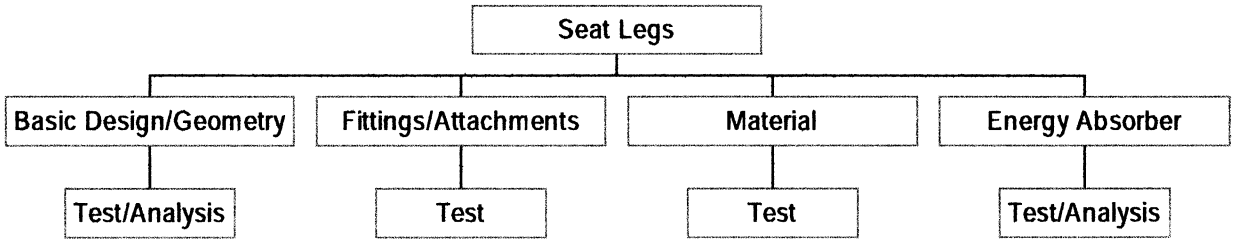
Holes or other minor variations to the seat leg that are not located in a highly stressed area are acceptable. For example, holes drilled in the leg web to attach under-seat electronics boxes are acceptable provided the hole is not in a highly stressed area of the leg.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Additional tests would be selected based on the role that the variation plays in the seat performance. For example, a material change to a portion of the seat leg may require an additional 16g forward structural test, but not require additional HIC or lumbar tests.

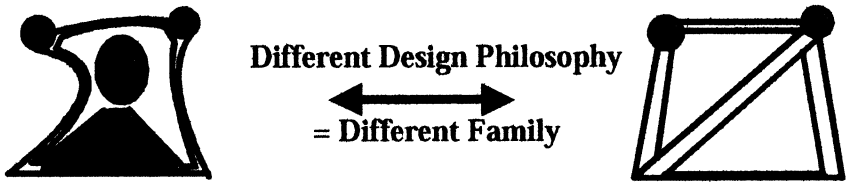
An additional test(s) must be performed for:

- Any seat with a seat leg geometry that is determined to be more critical with regard to strength, stiffness, or seat permanent deformation than the critical leg of a similar tested seat(s).
- Any seat with a seat leg energy absorber which has a variation in the load path, or which has a variation that affects the load rating or stroke/deformation of the energy absorber, from the seat(s) included in the baseline testing.

Static or dynamic component tests may be acceptable to substantiate variations to seat legs. Component test methods should be coordinated with the appropriate regulatory agency in advance of the certification program.



Note: Basic design/geometry includes small, local changes to the legs.
Fittings include attachments to cross-beams, fittings and spreaders.
Component tests may be appropriate instead of a full scale test.



3.2 Lateral Beams (Cross tubes)

a) *Family of Seat Principles* - Lateral beams (cross tubes) are typically the structural members that provide the load path from the fore-aft linkages (e.g., spreaders) and bottom cushion support to the vertical structure (e.g., legs). Lateral beams, at similar locations within the seat assemblies, must have the same design philosophy.

Two types of stiffeners are considered here. The first is a local doubler added to reinforce areas with high stress concentrations. A local doubler is defined as one whose length is of the same order of magnitude as the maximum cross-sectional dimension of the beam, e.g. one whose length is less than three times the maximum cross-sectional dimension of the beam. The second is a longer stiffener (e.g., nested tubes) used to increase beam stiffness and strength over a substantial part of the beam length. Lateral beams with long stiffeners should be treated as a different family, requiring a new, different test program since the dominant cross-section for the beam is different than other beams in the seat family.

Lateral beams can include local inserts within the family (e.g., doublers) which typically provide *local* strengthening of the beam. Inserts, at similar locations within the seat assemblies, must have the same material, manufacturing process and must have similar attachment methods. An insert configuration used in the primary load path (e.g., at the leg or spreader attachments) at all similar primary load path locations within the seat for all seats does not need additional substantiation beyond the baseline testing. For example, an insert included at any rear beam leg attachment should be included at all rear beam leg attachments for all seats in the family. Variations in geometry (length and thickness) are discussed below.

Nested tubes within a seat family must have the same material, manufacturing process and must have similar attachment methods. Variations in length are discussed below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - The following variations in local inserts are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s) (see appendix A).

- Insert thickness
- Insert length
- Insert location
- The elimination of a local insert in some locations of the seat assembly may be acceptable by rational analysis if the analysis *clearly* demonstrates the adequacy of the attachment without the insert.

Variations in the lateral beam length to accommodate differences in seat width are acceptable without additional test/analysis provided the seat is included in the interface load analysis used in the test article selection process in Section 4.0 of this concept paper.

Variations in nested tubes length and location are acceptable without additional test(s) provided it can be shown by rational analysis that the strength, stiffness, and seat permanent deformation are equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - The structural performance of any seat with a lateral beam or nested tube possessing a variation in material, geometry (except for length), or manufacturing process from the seat(s) evaluated by test.

An additional test(s) must be performed for any seat that:

- Does not have lateral beam doublers, if used, at all similar primary load path locations within the seat,
- Has lateral beam doublersthat has a variation in material, geometry (except for length or thickness), or manufacturing process from the tested seat(s).
- Has lateral beam doublersor nested tubes which has a variation in length that is determined to be more critical with regard to strength, stiffness, or seat permanent deformation than the tested seat(s).
- Has lateral beam doublersor nested tubes that has a variation in attachment method that is determined to be more critical with regard to strength than the tested seat(s).

3.3 Seat Spreaders

a) *Family of Seat Principles* - A Seat spreader is typically a fore-aft linkage between the lateral beams. Seat spreaders often provide the structural load path for other features of the seat (e.g., seat belt attachment, seat back attachment). Spreaders, at similar locations within the seat assemblies, should have the same design.

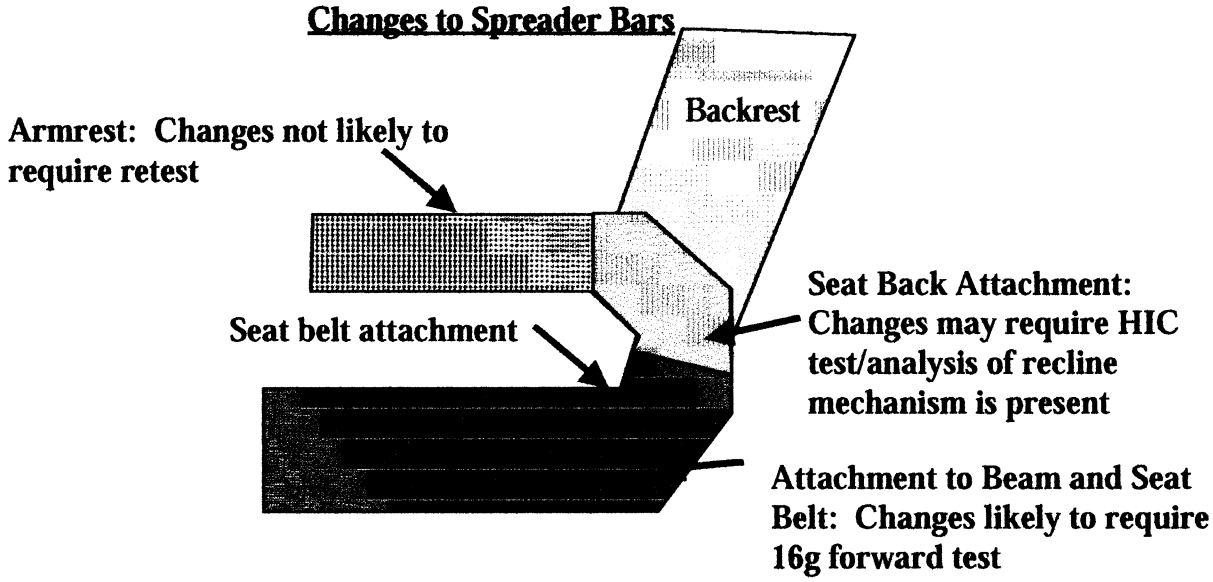
b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to parts of the spreader that are not in the primary load path (for example, between the seat belt/seat back attachments and the top of the armrest) are acceptable without additional test/analysis. For example, the area of the spreader that extends beyond the seat belt or seat back attachment that incorporates an armrest attachment. The armrest attachment may vary, provided:

- The variation does not extend into the seat back/seat belt load path,
- The variation does not affect any potential ATD head contact area from an occupant in the seat behind,
- It can be shown by rational analysis that the retention of the armrest is not significantly affected.

Variations to parts of the spreader that are in the primary load path (between the seat back attachments and the lateral beams/legs) are acceptable provided it can be shown by rational analysis that the strength (compression/bending) is equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional 16g longitudinal structural test must be added to the baseline testing for any seat with variations to parts of the spreader that are in the primary load path (between the seat belt attachments and lateral beams/legs).

An additional row-to-row HIC test may be required, if variations to the spreader in any seat are within the ATD head contact area from an occupant in the seat behind or change the seat back performance with regard to HIC.



3.4 Bottom Cushion Support

a) *Family of Seat Principles* - The bottom cushion support (e.g., seat pan or diaphragm) is the structure immediately below the bottom cushion supporting the occupant weight. The primary considerations for this component regarding variations/changes are the affect on structural performance, lumbar load performance in a 14g vertical test, and the positioning of the occupant in the seat place. The bottom cushion supports at all seat place locations must have the same materials, manufacturing processes, construction method, and they must be similar in geometry and method of attachment, with the exception of section (b) below.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat bottom cushion support geometry and method of attachment are acceptable without additional test(s), provided it can be shown by rational analysis, based on test data, that:

- The variations have no significant influence in increasing lumbar compression load (including deflection such that contact occurs with any item beneath),
- The strength is equivalent to or less critical than the tested seat.

The following variations are acceptable without additional tests:

- Variations in the bottom cushion support geometry to accommodate small difference in the seat place width (3 inches or less) provided other aspects of the geometry and the method of attachment do not vary.
- Variations in the bottom cushion support geometry having an influence on SRP location provided the SRP does not vary by more than 0.5 inch in any direction (fore, inboard, outboard, or up) from the SRP of the tested seat. In general, if all other features of a seat remain constant, head excursion with respect to the seat is shorter when the SRP moves aft. Similarly, structural loads due to overturning moments decrease as SRP is lowered. These general trends can be examined to eliminate duplication of some tests.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Test(s) are required for any seat with a variation in seat bottom cushion support material or construction method from the tested seat(s).

Test(s) are required for any seat with a variation in seat bottom cushion support that has significant influence on lumbar load (including deflection such that contact occurs with any item beneath) or that is determined to be critical with regard to strength than the tested seat(s).

If a variation in the seat bottom cushion support varies the SRP more than 0.5 inches in any direction from the tested seat, the following tests/analysis must be performed:

- A 14g lumbar load test
- 16g longitudinal structural test if the SRP moves upward.
- 16g longitudinal head path analysis (if one is included in the baseline testing). This analysis would graphically modify the head path collected in previous test(s) to account for the change in SRP.
- A row-to-row HIC test should be performed if the SRP moves up or forward more than 0.5 inches. If the SRP moves down or aft, graphical analysis of the data collected in previous testing should be used to determine if the head might strike a different object.

Note: The new SRP location is directly related to any modification to the structural geometry in the seat bottom cushion support. Therefore, no SRP measurements are required in determining the "new" SRP.

3.5 Bottom Cushion

a) *Family of Seat Principles* - The bottom cushion is the component that the occupant sits directly upon. The primary considerations for this component regarding variations/changes are the affect upon lumbar load and the positioning of the occupant in the seat place. Occupant position is assessed using the Seat Reference Point (SRP) as defined in AS8049 Revision A or later. Variations in SRP dimensions discussed in this document are in the component X, Y, and Z directions (the XYZ resultant change is not considered). The bottom cushion assembly (i.e. foam sandwich) must have the same material (including density, material and manufacturing process, etc.), must be either molded or fabricated within a family, and must be similar in contour and thickness.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Contour variations are acceptable without additional 16g & 14g structural tests provided the SRP does not vary by more than 0.75 inch in any direction (fore, aft, inboard, outboard, up or down) from the SRP of the tested seat. This 0.75 inches variation recognizes the inherent 0.25 inches tolerance in the SRP measurement in addition to an allowable design change of 0.5 inches. Experience has shown that geometry variations in an area three inches forward, two inches rearward and two inches sideward of each buttock reference point have the most influence on SRP.

Variations in seat cover fabric are acceptable without additional analysis. This is provided the variations do not significantly affect the SRP location.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must be performed for:

- Variation in bottom cushion material (excluding fabric and common fire-blocking material) would require a 14g vertical lumbar load test and 16g longitudinal head path test, if one were included in the baseline testing.
- Variation in cushion contour that moves the SRP location more than 0.75 inches up would require a 16g longitudinal structural test.
- Variation in cushion contour that moves the SRP location more than 0.75 inches in any direction would require a 16g longitudinal head path test, if one is included in the baseline testing.
- Any variation in the cushion contour in an area three inches forward, two inches rearward and two inches sideward of the buttock reference point of the previously tested cushion would require a 14g vertical lumbar load test.

3.6 Seatbelts and Anchors

a) *Family of Seat Principles* - The seat belts (occupant restraints) provide the load path from the occupant to the seat structure. The seat belt typically consists of a latching mechanism, a belt anchor (which connects the belt to the seat) and webbing (which links the latch mechanism with the belt anchors). The latching mechanism must have the same materials, manufacturing processes, construction method, means of webbing retention, and must be similar in geometry. The belt anchors must have the same materials, manufacturing processes, construction method, and must be similar in geometry. The webbing must have the same material, manufacturing process, construction method, and geometry. The stitching used to attach restraint system hardware to the webbing must be identical to the tested seat(s).

The goal is to have standards for seat belts that are sufficient to reduce or eliminate full scale testing when they are substituted on a seat family. To date, there are not sufficient standards to accomplish this. At this time, one or more full scale dynamic tests would be required to substantiate a seat belt replacement.

The quality and workmanship of the restraint system shall be consistent with TSO/JTSO C22 or TSO/JTSO C114 or equivalent.

The seat belt anchor provides the load path between the belt anchor (part of the belt assembly) and the seat structure (e.g. spreader). Seat belt anchor, at similar locations within the seat assemblies, must utilize the same materials, manufacturing processes, exhibit similar geometry and employ similar methods of attachment.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the seat belt anchor or latching mechanism, are acceptable without additional test(s) provided it can be shown by rational analysis that:
- The variation does not affect the means of webbing retention, and
- The strength and stiffness are equivalent to, or less critical than the tested seat.

Variations to webbing color, latching mechanism, belt anchor finish, part labeling, connector/buckle "handedness", latch handle disengagement angle, and adjustable-side webbing length are acceptable without additional analysis.

Variations of the fixed length of the restraint system is acceptable as follows:
- The adjuster mechanism moves closer to the centerline of a 50% ATD from the previously tested position (Unless the original position of the adjuster was at the extreme side of the occupant (i.e., at the anchorage point)).
- The adjuster mechanism moves to within ±1.5 inches of the centerline of a 50% ATD (reference FAA letter 96-114-3).

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must conducted for any of the following variations if it is determined to be more critical with regard to the component's performance in the dynamic test compared to the tested seat:

- Changes in anchor geometry and method of attachment would require substantiation by test. Some changes to the seat belt anchor may be acceptable without test (e.g., changing a bolt to one with higher strength).
- Latching mechanism material
- Manufacturing process
- Construction method
- Stitch Pattern

An additional test(s) must be performed for any seat with a seat belt anchor which has a variation in material, manufacturing process, construction method from the tested seat(s)unless substantiated by analysis (above).

Variations in the webbing or means of webbing retention in the latching mechanism must be addressed by parametric studies during 16g longitudinal tests (structural, HIC, head path).

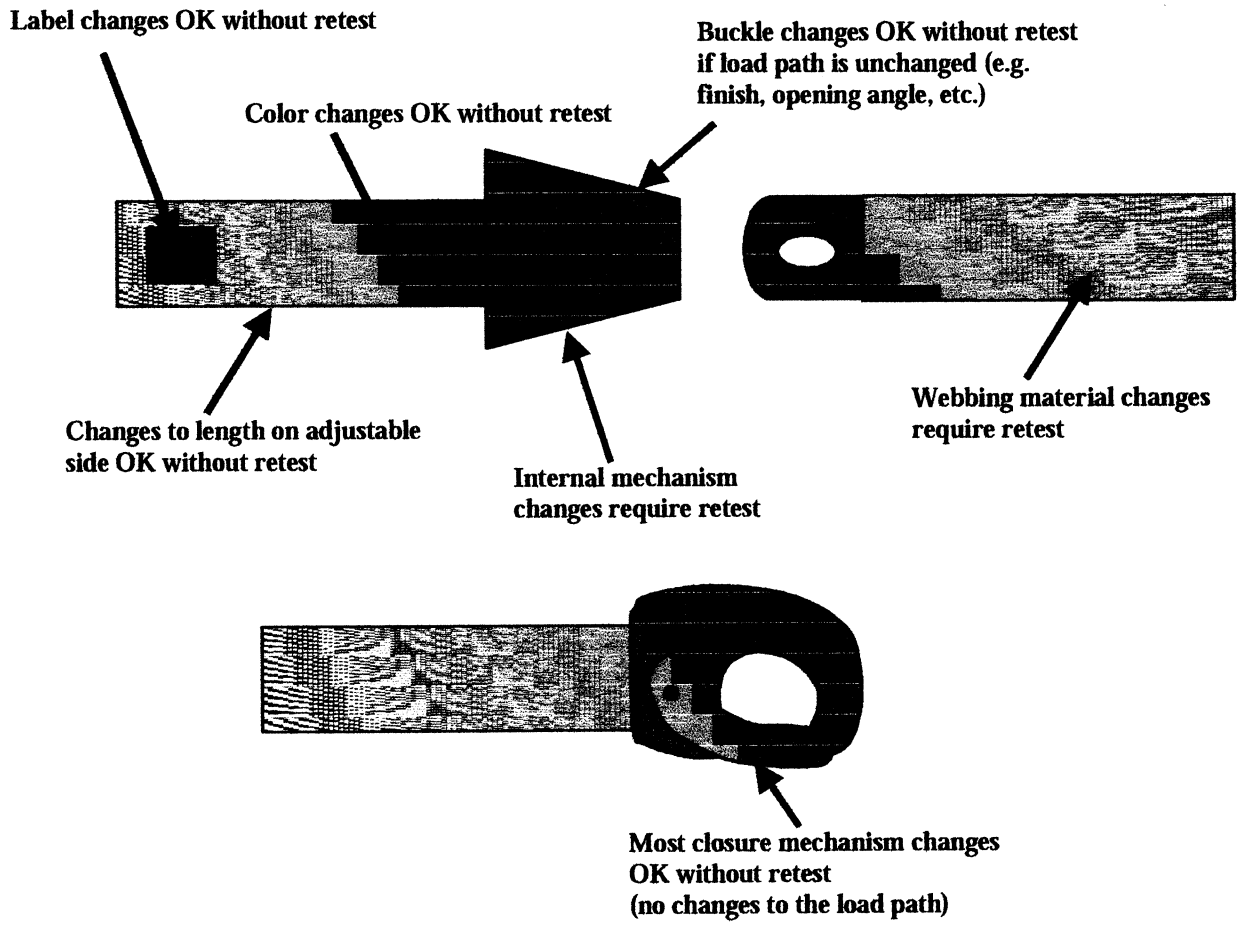
Once a belt system is qualified for a specific seat family it can replace other qualified belt systems on that same seat family. To qualify a new belt on an existing family, one 16g structural test seat with highest loaded leg (pitch and roll) must be performed. This structural substantiation is sufficient to allow use of the new belt on the seat family. The ATD head path must be compared for the seat with the new belt system and with the old belt system. This may be done on either the structural test noted above, or an additional 16g forward head path test depending on what data is available for comparison with the old belt system.

- If the head excursion along the entire path for the new belt system is equal to or less than the old belt system, no additional substantiation is required.
- If the head excursion along the entire path for the new belt system is greater than the old belt system, the installation limitations may need to be modified to account for this difference.

If multiple belts are a part of an existing seat family, and a seat component is changed in the family that will require additional testing, it is not necessary to retest with every seat/belt combination. Floor reaction loads for the 16g structural tests for each belt may be used in selecting a single belt for use on testing future changes to the seat family. This would cover all belts previously qualified using the same webbing material (e.g. nylon or polyester webbing). The belt used for this follow-on testing would be the one associated with the highest floor reactions.

Note: If the test using the new seat component generates significantly higher floor reaction loads (load increases on the order of 10% or more) compared to the test without the new seat component, the belts that were not tested must be addressed to ensure they have sufficient strength. A plan outlining additional test and/or analysis of the non-tested belts must be reviewed with the appropriate regulatory agency.

Seat Belts



3.7 Attachments between structural members

a) *Family of Seat Principles* - Fittings and fasteners provide the primary load path between structural components. These include, but are not limited to, the connection method of the spreader-to-beam attachment, beam-to-leg attachment, and leg-to-track fitting attachment. In general, these attachments should reflect similar design philosophy at similar locations within the seat assemblies (e.g. the attachment method between the lateral beams and the seat legs should be consistent between seat assemblies).

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to the attachments between structural members due to space/geometry limitations are acceptable without additional test(s) provided
- The attachment has the same design philosophy, and
- It can be shown by rational analysis that the strength and stiffness are equivalent to or less critical than the tested seat.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must conducted for any seat with an attachment that reflects a different design philosophy (e.g., a beam-to-leg attachment with a spreader clamp design vs. a saddle design) from the seat included in the baseline testing.

An additional test(s) must be conducted for any seat with an attachment which reflects the same design philosophy but is determined to be structurally more critical than the attachment between structural members of a similar seat included in the baseline testing.

A single 16g longitudinal or 14g vertical test is sufficient to substantiate the attachment between structural members, with a different design philosophy or variations within the same design philosophy, provided it can be determined which test condition is critical for that attachment.

3.8 Seat track fittings

a) *Family of Seat Principles* - Seat track fittings are critical components in the primary load path.

The seat track fitting provides the load path between the seat primary structure (e.g., leg or beam) and the aircraft structure (e.g., seat track). Seat track fittings must have the same load path and similar design philosophy.

b) *Variations and Post Certification Changes Acceptable by Analysis* -

Variations to the seat track fitting locking mechanism engagement/adjustment device (screw, bolt, etc.) are acceptable without additional analysis provided it is not part of the load path, or does not change the load path (for example, by altering stud engagement).

Variations in seat track fitting finish are acceptable without additional analysis provided the method of finish application does not affect the strength of the part.

c) *Variations and Post Certification Changes Requiring Additional Tests* - Variations in seat track fitting geometry or method of attachment must be substantiated by test(s).

An additional test(s) must be performed for any seat with a seat track fitting which has a variation in load path, material, manufacturing process, construction method from the tested seat(s).

3.9 Energy Absorbers in Seat Leg Structures

a) *Families of Seat Principles* - Energy absorbers (EA devices) are typically incorporated in the seat leg structure to control occupant and/or structural loads. Within a family, energy absorbers must share a consistent design. While the incorporation of energy absorbing features is encouraged, the criticality assessment is not as straightforward as for other parts of the primary load path.

If all seat leg/EA combinations are identical, the normal seat dynamic test program that tests the structurally critical seat will also substantiate all the seat leg/EA combinations in this case. No additional tests are required.

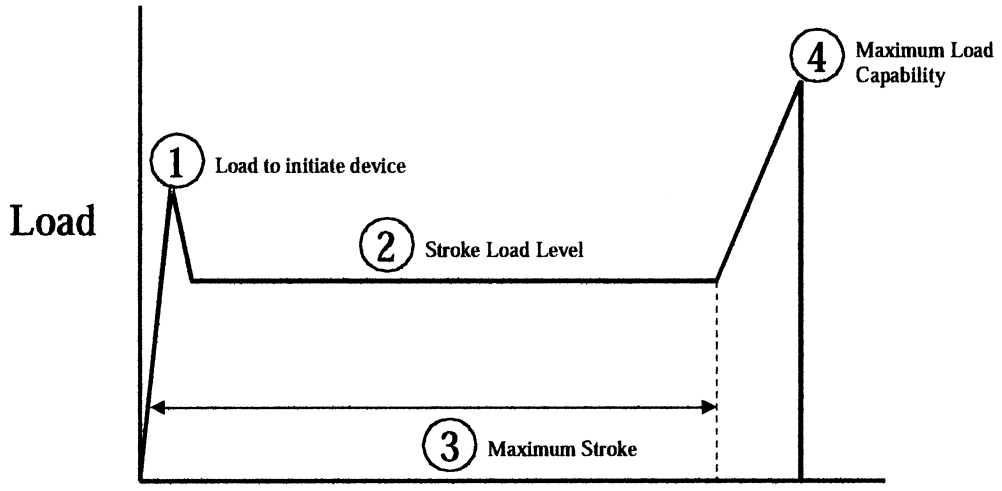
b) *Variations and Post Certification Changes Acceptable by Analysis* - When the seat leg structures are identical at all locations, but different rated EA's are at some seat leg locations (the EA's use the same design philosophy, and the EA's end attachments are identical), the leg structure must be substantiated for the highest load and the stroke of each EA device must be substantiated as follows:

Substantiation of the Leg Structure and Attachment - The normal seat dynamic test program that considers the structurally critical seat will also substantiate all the seat leg/EA combinations if none of the EA's stroke or if only the highest rated EA strokes. Either of these test results will ensure that the highest seat/floor interface loads were developed.

Substantiation of the EA Stroke - In general, a lower rated EA device should not 'bottom-out" unless the highest rated EA also "bottoms-out". In any event, additional tests may be required to test the lower rated EA device(s) in order to establish the highest seat/floor interface load for that device, should any EA other than the highest rated EA "bottom-out" during the test.

In all cases, additional tests must be performed, critically testing the lower-rated EA devices, or the supplier must work with the appropriate regulatory agency to develop a validated predictive model for the EA devices in order to provide an adequate rational analysis in order to avoid additional tests.

The following steps outline the considerations to be used in performing a predictive rational analysis used to substantiate seat legs with different rated EA devices. This analysis should be successfully completed prior to conducting dynamic tests in order to demonstrate that there is adequate testing of the energy absorbing system and the affected seat structure:



- The fundamental performance should be characterized in terms of the maximum load capability, the load to initiate the EA device, the stroking load level, and the amount of stroke/deformation available. These parameters all need to be determined.
- Using the static interface loads and knowledge of the EA characteristics the expected performance of each EA (i.e., stroking load level and stroke length) should be predicted;
- Correlate the analytical predictions and the results of the dynamic test to ensure that during the dynamic test all EA's have performed as designed.
- Demonstrate that none of the seat/EA combinations would bottom out under their maximum load case.

EA variations that do not affect the fundamental performance, or make the stroke/deformation of the EA more critical, may be allowed without retest.

c) *Variations and Post Certification Changes Requiring Retest* - If a seat assembly has different leg structure and different rated EA's at some locations, each seat leg/EA combination must be demonstrated by tests to produce that the maximum seat/floor interface load for each individual seat leg/EA combination. This is necessary to ensure that the maximum seat leg/EA load is developed for each combination and that adequate stroke is available at each individual EA.

3.10 Seat Backs

a) *Family of Seat Principles* - The seat back supports the occupant's torso in the seated position. It is the component of the seat that is typically forward of an occupant in a row-to-row HIC situation (forward facing seats), and is the component of the seat which provides the load path to the lower seat structure in aft facing installations. The permanent deformation of seat backs can be a significant consideration for the occupant egress of the airplane. The primary consideration for this component regarding variations/changes are the affects on seat back position/angle and occupant positioning (which may affect HIC or lumbar load), the affect on structural performance and seat back permanent deformation.

The components installed on the seat back (e.g., food tray tables, video monitors, telephones, etc.), must be represented when evaluating variations/changes, as well as the recline mechanism, breakover devices, seat back energy absorbers, and seat back attachment hardware.

The seat back structural components and attachment hardware must have the same materials, manufacturing processes, construction method and they must be similar in geometry.

The seat back energy absorbers must be the same for all seat backs for all seats that are subject to the HIC criteria.

The seat back breakover must be the same for all seat backs for all seats that are subject to the HIC criteria.

When a load is applied to the seat back in the upright position, the load path within recline mechanism(s) from the seat back to the seat structure must be the same for all seat backs that are subject to the HIC criteria.

The seat back breakover must be the same for all seat backs for all seats.

Seat backs should be interchangeable between most families if the seat back accessories, back structure and method of attachment perform the same.

Once substantiated for HIC, seat backs can be arranged independently in the aircraft (subject to pitch limitations of the target seats). For example, once the business class seats pass the HIC testing, they can be installed in the aircraft with an economy class seat behind without further substantiation. Exceptions include it being paired with a seat with very unusual performance (e.g. very large deformation, substantial energy absorption, etc.)

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to components installed on the seat back are acceptable without additional test(s) provided the test article selection process in Section 4.0 (considering the component variance) shows the seat(s) selected for the row-to-row HIC tests are the seat(s) that was tested.

Variations to the attachment method of components installed on the seat back are acceptable without additional test(s) provided:

- For retention, it can be shown by rational analysis that the strength is equivalent to or less critical than the tested seat(s), and
- This does not replace the test in Section 4.0 for row-to-row HIC

Variations to the seat back, excluding potential head contact areas, which do not significantly affect the mass/weight, center of gravity or load path stiffness of the seat back (e.g., cushion trim, dress cover, etc.) are acceptable without additional analysis.

Variations of the seat back structure width up to two inches are allowed without additional test as long as these variations in seat width do not introduce new structure in the target head strike area. Variations greater than 2 inches may require additional test(s) for HIC and B/C deformation.

Variations in the seat back upright position of ±3° are acceptable without additional analysis provided it can be shown that the variation has no influence on occupant egress from the airplane when evaluated using the seat permanent deformation data from the baseline tests (reference AC 25.562-1A). For example, applying the seat permanent deformations from the baseline tests to the "new" seat back upright position still meets the guidance for occupant egress, including 'B' vs. 'C', given in AC 25.562-1A. Additional variations in the upright position are acceptable with analysis that the variations doe not influence HIC or egress for the person in the seat, or the person behind the seat.

Variations to backrest cushion hardness and contour are acceptable provided the SRP does not vary by more than 0.75 inch from the SRP of the tested seat.

Variations to any part of the recline mechanism which does not provide a load path from the seat back to the seat structure are acceptable without additional analysis.

c) *Variations and Post Certification Changes Requiring Retest* - Variations in the seat back structure materials, manufacturing processes, or construction method from the tested seat(s) may require retest.

A HIC test(s) must be performed for any seat with a seat back (subject to the HIC criteria) which has a variation in an installed component that the test article selection process in Section 4.0, when considering the component variance, shows must be tested in addition to the tested seat(s).

A test(s) must be performed for following seats if they are required to meet the HIC criteria:

- Any seat with a seat back that has a variation in the attachment method of an installed component that has been determined to be more critical than the tested seat(s).
- Variations in the seat back attachment method, which the test article selection process in Section 4.0 shows must be tested in addition to previously tested seat(s).
- Variation in the seat back energy absorber from the tested seat(s).
- Variation in the seat back breakover from the tested seat.
- Variation to any part of the recline mechanism which provides a load path from the seat back to the seat structure from the tested seat. If a part of the recline mechanism is not considered critical in the HIC load path, variations which do not lower the strength of the load path are acceptable without test. For example, the recline mechanism can be replaced with a "solid rod" because other components in the HIC load path absorb the energy of a seat back head strike.
- Variation in backrest cushion hardness or contour that varies the SRP location more than 0.75 inch in any direction from the seat back to the seat structure from the tested seat.
- Variation in the seat back upright position of greater than ±3° from the seat back to the seat structure from the tested seat, unless an acceptable analysis is provided per section (b) above.

3.11 Seat Weight

a) *Family of Seat Principles* - The seat weight has a significant influence on the seat performance during the structural tests. Small weight variations are acceptable, but large increases must be substantiated by test. These variations are accounted for in the critical test case evaluation by interface load comparison, and mass retention evaluation. Proper planning of test article definition and testing can make accommodation of future seat weight growth. This can be accomplished by adding ballast to the test article.

b) *Variations and Post Certification Changes Acceptable by Analysis* - An increase in the seat weight of a seat that was included in the baseline testing is acceptable without additional test/analysis provided the increase is not greater than 3% of the total unoccupied tested seat system weight. It is understood that 3% is the current focus of the SAE seat committee for weight increases without test. If the SAE committee selects an alternate criterion, this would be adopted as an acceptable standard.

An increase in the weight of a seat that was not included in the baseline testing (i.e., a seat that was not tested per the test article selection process) is acceptable provided:

- The test article selection process in Section 4.0, using a seat interface load analysis with the increased seat weight, shows the seat(s) selected for the structural tests to still be the tested seats.
- If the weight increase to any seat is due to adding a specific item to a specific location on the seat:
  - Retention of the added item must be addressed from the component to the primary structure of the seat:
  - For items where the strength of the attachment method is the only issue, a static analysis/test may be sufficient.
  - For items that are likely to affect the dynamic response of the seat, dynamic testing must have substantiated local retention of a similar item of representative weight and attachment.
  - Depending on the location of the added component, testing of the component in question for retention may be conducted on a partial or unoccupied seat. These types of tests should be coordinated in advance with the appropriate regulatory agency.
- Testing must have substantiated HIC if ATD head contact with the added item is possible.
- Testing must have substantiated lumbar load if ATD contact with the added item is possible.

c) *Variations and Post Certification Changes Requiring Additional Tests* - An additional test(s) must be added to the baseline testing for any seat that was included in the baseline testing with a weight increase greater than 3% of the unoccupied tested system seat weight.

An additional test(s) must be performed for any seat that was not included in the baseline testing with a weight increase if the test article selection process in Section 4.0, using a seat interface load analysis with the increased seat weight, determines that this seat should be selected for testing.

An additional test(s) must be performed for any seat with a weight increase due to adding a specific item to a specific location which was not substantiated in the baseline testing for retention of the item, HIC, or lumbar load (as appropriate).

A dynamic test of the seat with no occupants or a static test using an appropriate load factor may be acceptable to substantiate retention of an item of mass on the seat.

3.12 Armrests

a) *Families of Seat Principles* - Armrests are the seat structures that retain the occupant's sides. They are not required features on a seat and many passenger places can have armrests on one or both sides of the passenger stowed (folded up). They may influence the lumbar criteria in the 14g down test if the ATD's arms rest on them. The primary considerations for this component regarding variations/changes are the affect on retention of the component, HIC (head contact on aft part of armrest from occupant seated behind), occupant egress of the airplane (seat permanent deformations), and positioning of the occupant in the seat place.

b) *Variations and Post Certification Changes Acceptable by Analysis* - Variations to armrests are allowed provided:

- It can be shown by rational analysis that the variations have no influence on the ATD dynamic response.
- It can be shown by rational analysis that the variations have no influence on occupant egress from the airplane when evaluated using the seat permanent deformation data from the baseline tests (reference AC 25.562-1A).
- The test article selection process in Section 4.0, considering the seat with the armrest geometry variance, show the seat(s) selected for the row-to-row HIC tests have been tested
- Variations to the armrest attachment can be shown by rational analysis that the strength is equivalent to or less critical than the tested seat(s).

c) *Variations and Post Certification Changes Requiring Additional Tests* - Variations to armrests that are in a potential occupant head-strike location should be substantiated by test/analysis.

An additional test(s) must be added for any seat that has an armrest which has a variation in attachment method that is determined to be more critical with regard to strength than the seat(s) included in the baseline testing.

An additional test(s) may be required if changes to the armrests influence the ATD response to lumbar loads. For example, if the seat geometry forces the ATD's arms over the armrests during a test, and a post-test modification to the armrest would significantly change the ATD response, an additional test may be required.

An additional row-to-row HIC test may be required to be added, if geometry or material variations to the armrest in any seat are within the ATD head contact area from an occupant in the seat behind.